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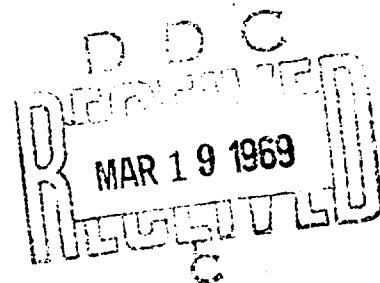
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V/STOL HEAD UP DISPLAY WORK AT
ROYAL AIRCRAFT ESTABLISHMENT, FARNBOROUGH

LIEUTENANT COMMANDER F. P. MARTIN, USN

6 MARCH, 1969



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V/STOL HEAD UP DISPLAY WORK
AT RAE, FARNBOROUGH

With the current world interest running high in V/STOL aircraft of all kinds, work in filling the vacuum that has always existed for these aircraft (helicopters, for example) with regard to instrumentation is beginning to pick up also. That's great, since helicopter pilots right up to the present time have had to make do with the same instrumentation that was developed eons ago for fixed wing use. Many of these instruments just are not adequate when flying low and very slow--nor were they designed to be. For example, the airspeed indicator in most aircraft is not reliable prior to reaching 30 knots. In a fixed wing aircraft that always operates from runways or even aircraft carriers, lovely, but V/STOL aircraft and helicopters--look in SEA today--spend a great deal of their time operating near or below 30 knots. Indeed, this may be the most important portion of the mission in the case of an air-sea rescue craft.

At any rate, helicopter pilots are tired of leftovers, and V/STOL pilots will want the top of the line. Ask any US Marine N.A.

At RAE, Farnborough, Dave Walters, Les Mayhew and their cohorts are about to begin evaluation of Head up Displays which could eventually be used for the Hawker-Siddeley Harrier. The display will be flown in one of the last prototype Kestrels. Flights are scheduled to begin in late March or early April.

The Harrier already has a display being built for it by Specto Avionics, Feltham, UK. What RAE is doing though, is trying a new approach to try to determine what pilots would like to be told. The question is, would they like to be told what is necessary to be done and how to do it? Or, would they prefer to have a choice of the method of accomplishment, if such choice exists?

Specifically, in the case of V/STOL aircraft, there is a difference in the control responses when wing-borne from that when jet-borne. Pull back the stick when wing-borne, airspeed decreases, altitude increases, while the same control movement when fully jet-borne produces a nose up attitude, but leads to rearward motion and generally a loss of altitude--assuming constant power is maintained.

Somewhere along the approach path of the V/STOL aircraft which is making a transition from wing-borne to jet-borne flight, this control transition also occurs.

In designing a head up display for V/STOL aircraft, two approaches were considered by the RAE avionics department. The basic HUD symbology from which work began is shown in Figure 1. The first modification to the basic display of Figure 1 is called (by RAE) the Control Director Display and includes the addition of the director dot, the throttle T and the nozzle symbol. These are shown on the display in Figure 2. The eyes are guided to the director dot by the lines arranged in a triangle with the dot at the apex. The short lines remain parallel to the horizon symbol. The dot shows required stick movements for altitude control. The "T" indicator is driven in a vertical sense only and corresponds with fore and aft movements of the throttle lever. The third symbol, "<", is also driven only in the vertical sense and corresponds to movements of the nozzle control lever. Ideally, the pilot maintains the horizontal bar of the "T" and the point of the "<" on the horizontal extensions of the aircraft symbol. In Figure 2, the actions required by the pilot are:

1. move stick forward and starboard (director dot)
2. move throttle aft to decrease power (T)
3. move nozzle control lever forward to accelerate (<)

Inputs to the controls are based on control laws which will give the pilot proper instructions wherever he is on the approach flight path.

The Guidance Display is shown in Figure 3. Two symbols are added to the basic display of Figure 1, namely dot with guide lines, and a trapezium shape associated with the landing area. Here, the dot indicates to the pilot, whether wing or jet-borne, that he is required to control aircraft height. It does not, however, tell him how to achieve this. The trapezium shape is used to control forward speed and therefore fore and aft acceleration. The trapezium normally remains out of sight in the upper portion of the display until the approach to a landing pad is begun. It requires inputs to stabilize it with respect to the landing pad. After the approach has begun and speed is reduced to say 150 kT, as the range from pad to aircraft drops, the symbol (trapezium) moves from the top of the display toward the center directing the pilot to begin deceleration. Again, it does not tell him how to decelerate. By matching deceleration with the display (trapezium) demands, and height with dot demands, the pilot should arrive over the pad at whatever preselected altitude he has chosen at which time the trapezium will be in the center (i.e. aircraft symbol centered on trapezium) and the height dot would be inside the aircraft symbol.

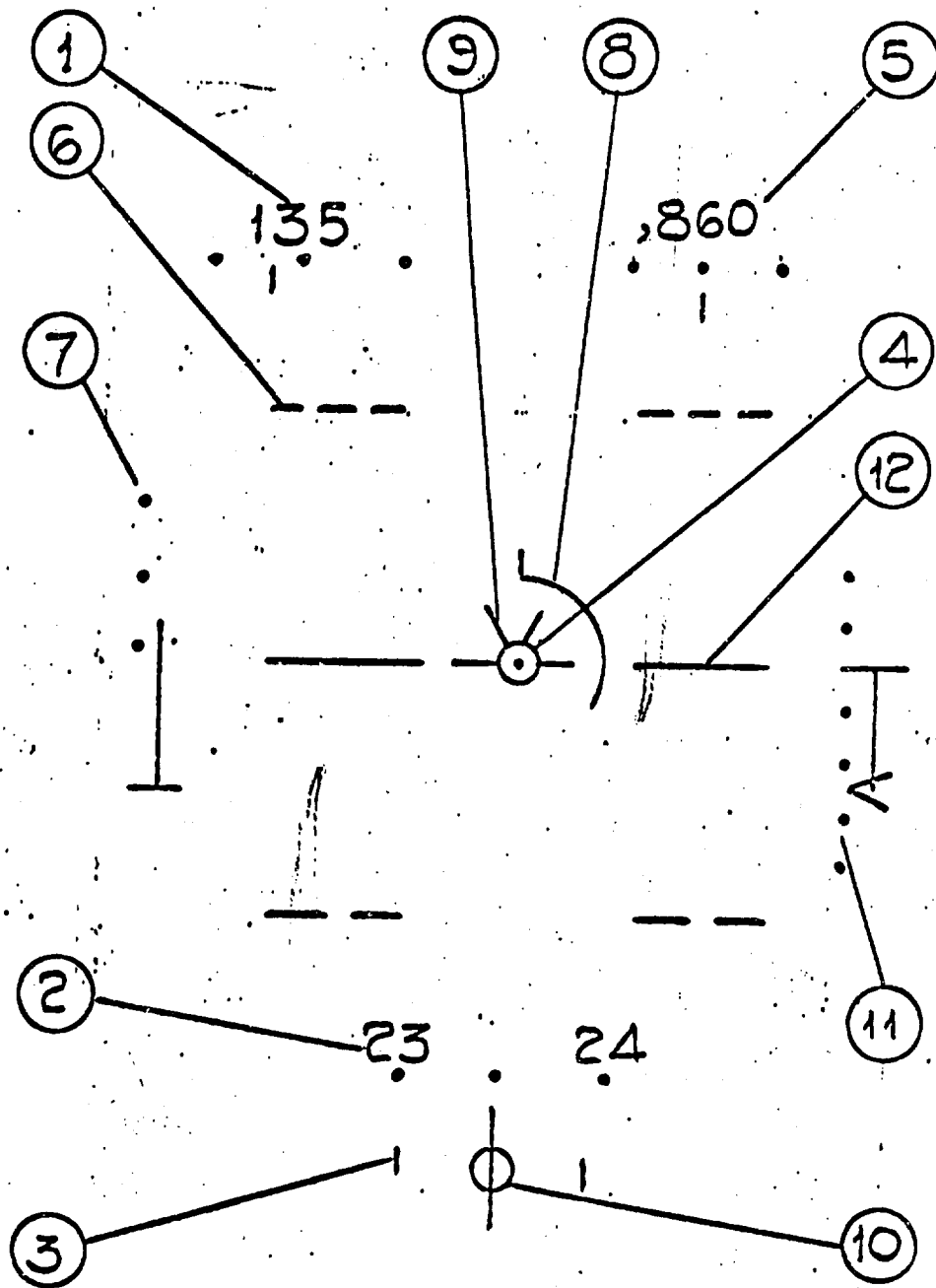
I have flown both of these displays on the RAE V/STOL Simulator and prefer the Control Director Display. However, at the time, the visual simulation portion was out of commission and I didn't get a fair test. I'll remedy this soon.



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- | | |
|----------------|-----------------|
| 1 AIR SPEED. | 7 ADD. SCALE. |
| 2 HEADING. | 8 RANGE CIRCLE. |
| 3 SLIP LIMITS. | 9 EVENT MARKER. |
| 4 A/C SYMBOL. | 10 SLIP BUBBLE |
| 5 HEIGHT. | 11 V.S.I. |
| 6 PITCH BAR. | 12 HORIZON. |

Fig. 1 Basic form of head-up display.

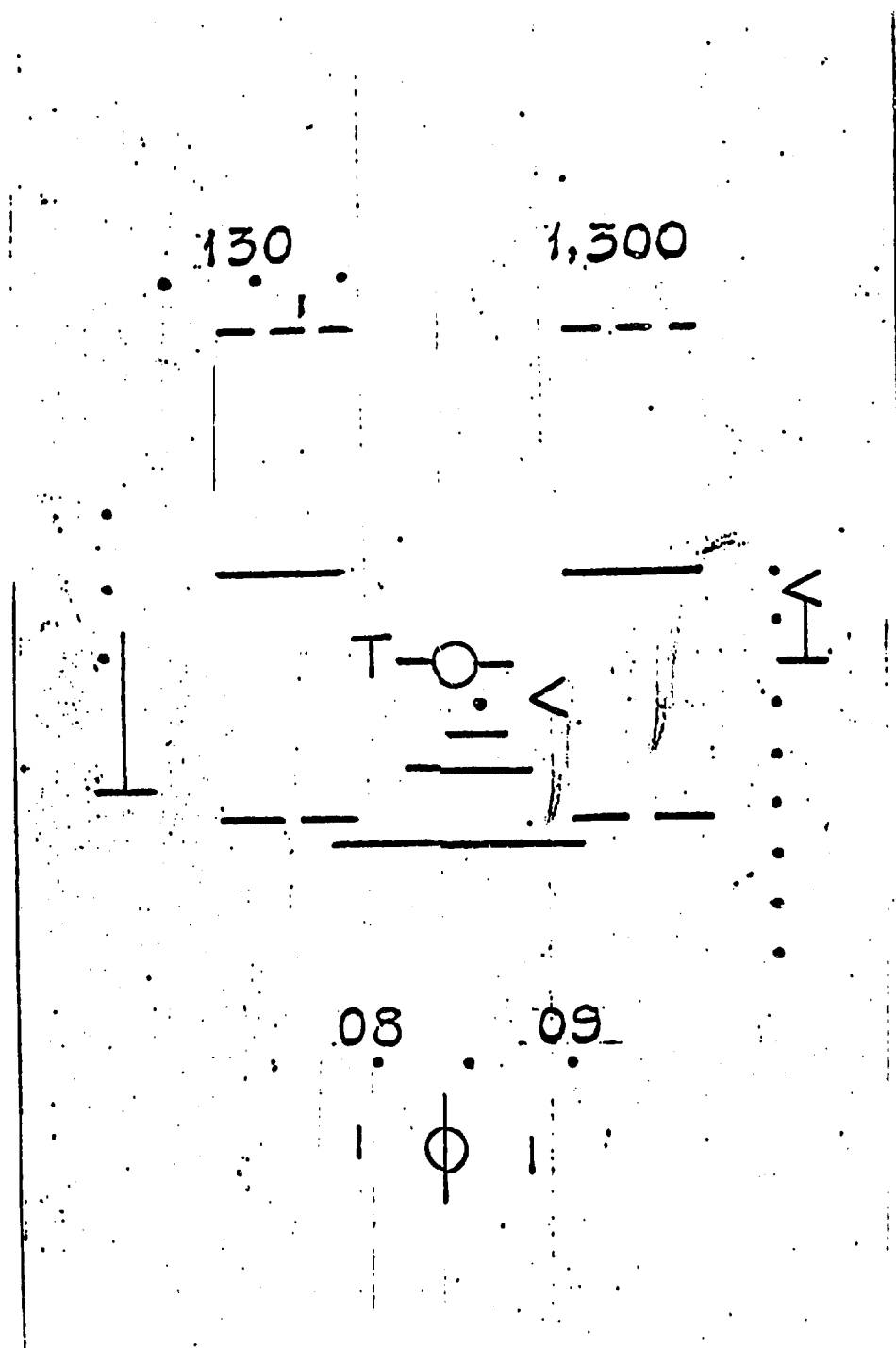


Fig. 2 Control director display.

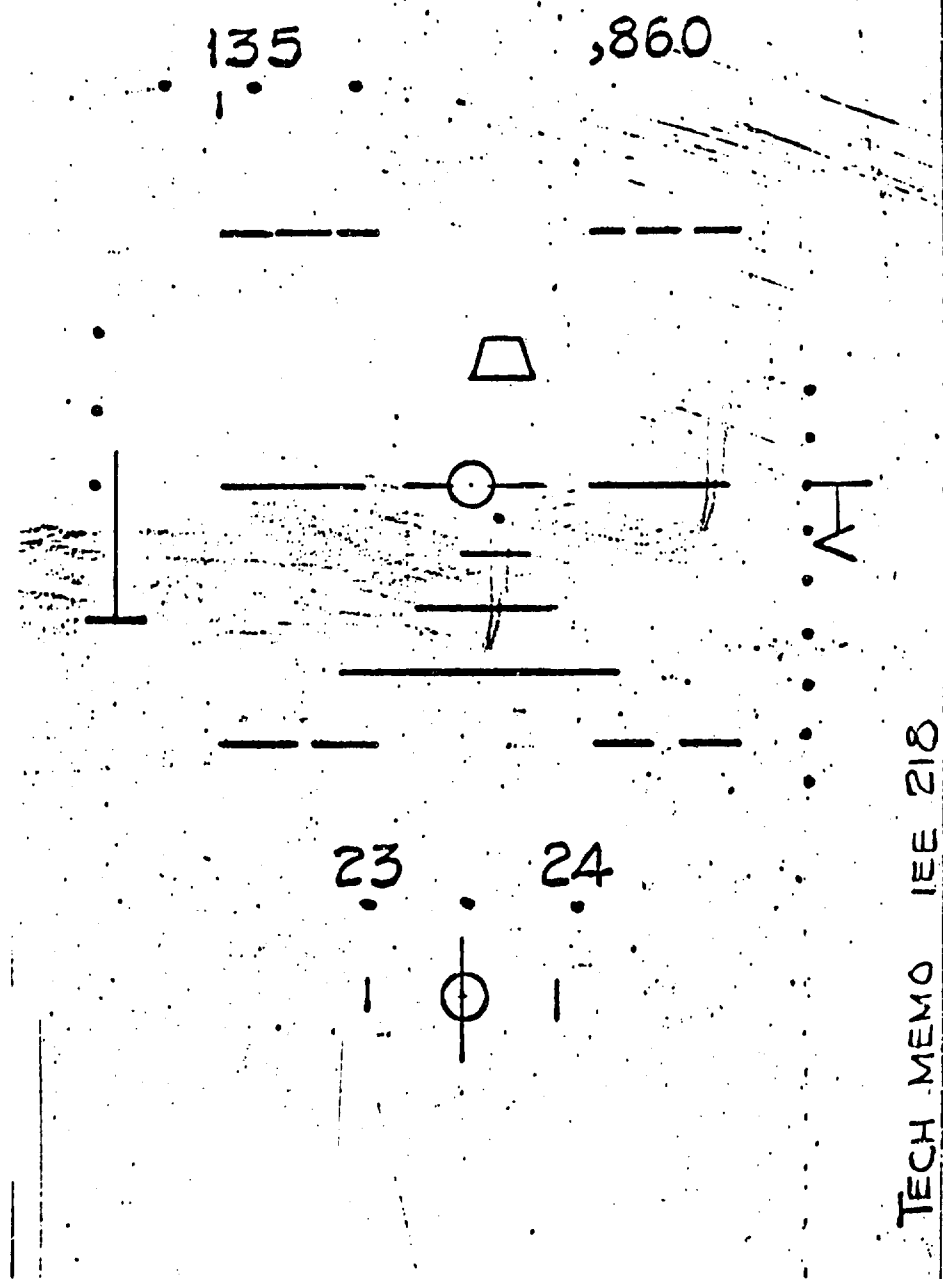


Fig. 3 Guidance display.

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13. ABSTRACT This report covers some of the new work being done at RAE Farnborough on Head-up Displays for V/STOL aircraft. Testing of displays discussed will begin at RAE in April 1969 using a Kestrel aircraft.			

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